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QUALITATIVE ANALYSIS OF VARSHA FORECASTS USING VARIOUS INPUTS – A STUDY AT FLOSOLVER

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ABSTRACT: *Varsha, a hydrostatic spectral general circulation model developed at Flosolver, NAL is used for forecasting the monsoon from the year 2005. Generally, significant variations are noted in NWP model forecasts, if the initial conditions are taken from different sources and also if the input parameters are slightly perturbed. The influence of perturbations in specific humidity and Sea Surface Temperature (SST) and the initial conditions from ECMWF, Reanalysis and Final Analysis data of NCEP on forecasts is studied using Varsha GCM. The results show that the initial conditions of specific humidity have a crucial role in rainfall forecasts. The persistent anomaly method applied for SST also provides a better rainfall forecast. It is also seen that the ECMWF data gives the better initial conditions to the model than other sources.*

1. INTRODUCTION

Varsha, a hydrostatic spectral general circulation model developed at Flosolver, NAL is used for forecasting the monsoon from the year 2005. The model forecasts have been compared with observations from India Meteorological Department (IMD). The initial conditions are taken from the Final analysis (FNL) data of National Centre for Environmental Prediction (NCEP). A wide variation is noted in the forecasts, if the initial conditions are taken from different sources and also if the input parameters are slightly perturbed. A study has been conducted in Flosolver to get an in depth knowledge of the influence of various input parameters and the initial conditions from various sources on forecasts using Varsha. The inference of the study is presented in detail here.

2. BACKGROUND

Varsha can be run at different spectral truncation, horizontal grid resolution and vertical layers. The initial conditions were prepared using the FNL dataset of NCEP which is available at 1 degree resolution. The model resolution has been chosen to be 120 spectral modes and a horizontal grid of 512x256 (approx 80Km at equator) and 18 vertical layers. Varsha is used for one month forecasts during monsoon months since 2005. Hindcasts for 20 years prior to 2005 were carried out and the results were analysed [1]. Model outputs, such as wind, precipitation and temperature are analysed and compared with observations from NCEP and all India daily and monthly rainfall are computed and compared with IMD observations.

3. DATA ANALYSIS AND METHODOLOGY

3.1 Moisture conversion

The FNL data consists of relative humidity (R_h), which is converted to specific humidity (q) to be used in the model. This conversion involves some approximations and depending on it, the values of specific humidity also vary.

The relative humidity, expressed as percentage, is the amount of moisture in the air divided by the maximum amount of moisture that could exist in the air at a specific temperature. The moisture calculation mainly includes the variables, namely, vapor pressure (e), saturation vapor pressure (e_s), mixing ratio (w) and saturation mixing ratio (w_s). The different ways to convert relative humidity using these variables [2] are discussed below.

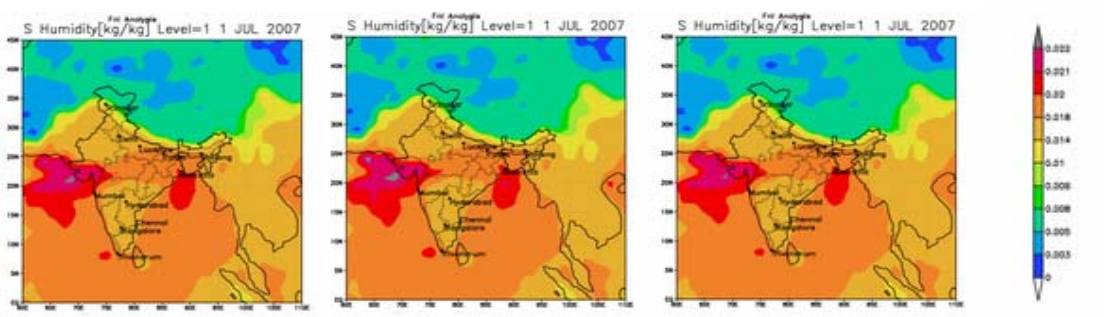
- Method 1:

$$q = \frac{e\varepsilon}{(\varepsilon - 1)e + P} \qquad (1)$$

• Method 2: $$q = \frac{R_h e_s \varepsilon}{R_h e_s (\varepsilon - 1) + P} \quad (2)$$

• Method 3: $$q = \frac{R_h e_s \varepsilon}{e_s (\varepsilon - 1) + P} \quad (3)$$

where P is the atmospheric pressure and ε = 0.622, the ratio of the molecular weight of dry air to the molecular weight of water vapour. Surface specific humidity over Indian region derived using the above three methods are shown in Figure 1. It can be seen that there is not much spatial and intensity variation visible from these plots.



(a) Method 1 (b) Method 2 (c) Method 3

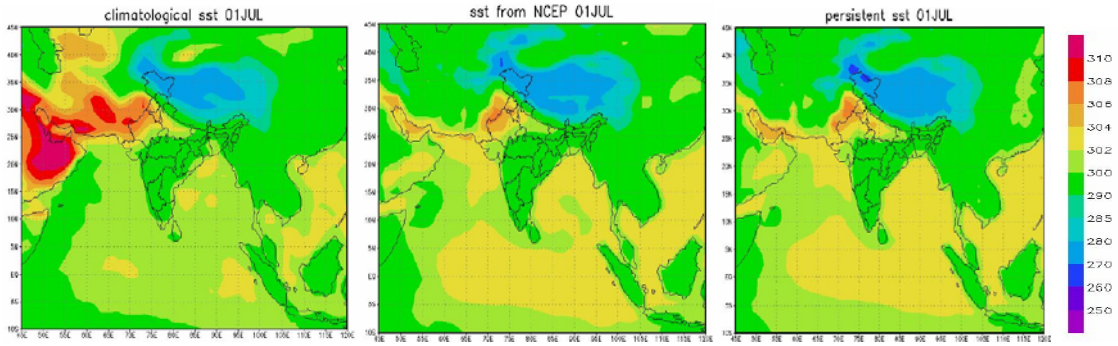
Fig 1. Specific humidity for 01 JUL 2007 derived using different approximations

3.2 Influence of Sea Surface Temperature

Studies are conducted to examine the forecasts, by changing the SST fields in three different ways, since the forecasts relays on SST to a great extent.

1. The daily SST interpolated from the monthly climatological data of 50 years prior to 2000 from NCEP.
2. Fixed SST. i.e., the SST of the initial condition will be used for the all the days.
3. SST derived using persistent anomaly method [3] which incorporates the effects of climatological as well as the latest trends in the ocean.

Figure 2 shows the spatial representation of climatological SST, the actual SST and SST derived using persistent anomaly method on that particular day over India respectively.



(a) Climatological SST (b) Actual SST (c) Persisted SST

Fig 2. Climatological, persistent and actual SST of 01JUL 2007

3.3 Effect of data from different sources

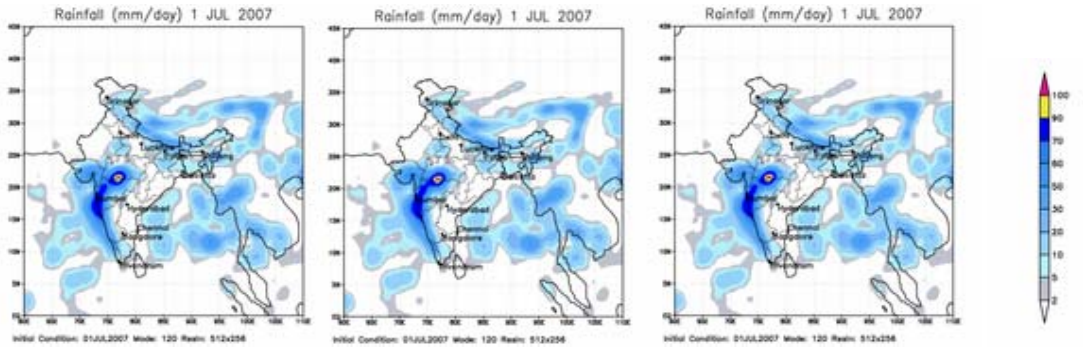
The influence of initial conditions on the GCM forecasts are well known. Small changes in the initial conditions from different sources are expected. But in some cases the differences are quite large, producing considerable departure in forecasts.

The procured meteorological data from European Centre for Medium range Weather Forecasting (ECMWF) [4] is in spectral form with a frequency of 106. The reanalysis data from NCEP [5] is also in spectral form with 62 modes. The Final analysis (FNL) data from NCEP [6] is in gridded format and on pressure levels. All these data needs preprocessing before giving to the model.

4. RESULTS

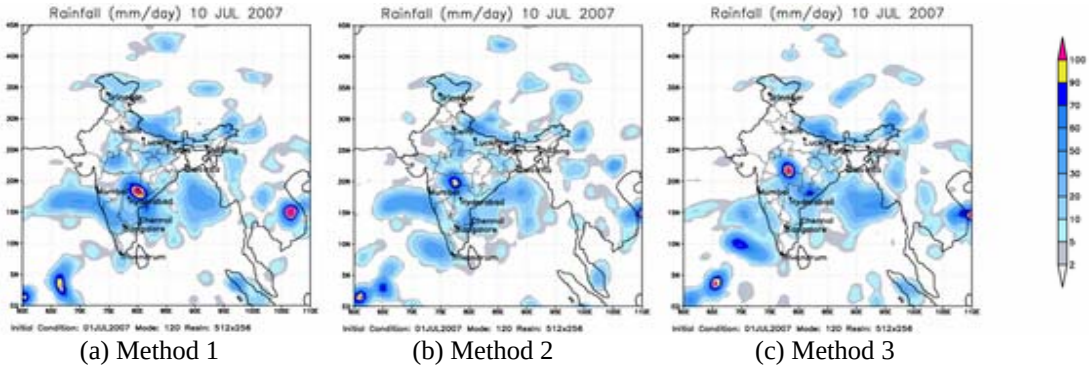
The results of various cases mentioned in section 3 are given below.

1. Small variations in the initial conditions of specific humidity (fig.1) resulted in large variations in the rainfall forecasts. As the meteorologists are mainly interested in rainfall, the precipitation forecasts are analysed in detail. The forecast of rainfall using three different initial conditions derived from the three methods discussed in section 3.1 are shown in figure 3 - 4. It can be seen that the difference between the rainfall forecasts using the three different approximations is negligibly small for the first day (see fig 3a-c). But it's interesting to see that as the forecast day progresses; the difference between them also increases. The rainfall forecast for tenth day is given in figure 4 (a - c), which clearly show the deviations. This difference puts the modeler in dilemma in deciding which approximation is to be used.



(a) Method 1 (b) Method 2 (c) Method 3

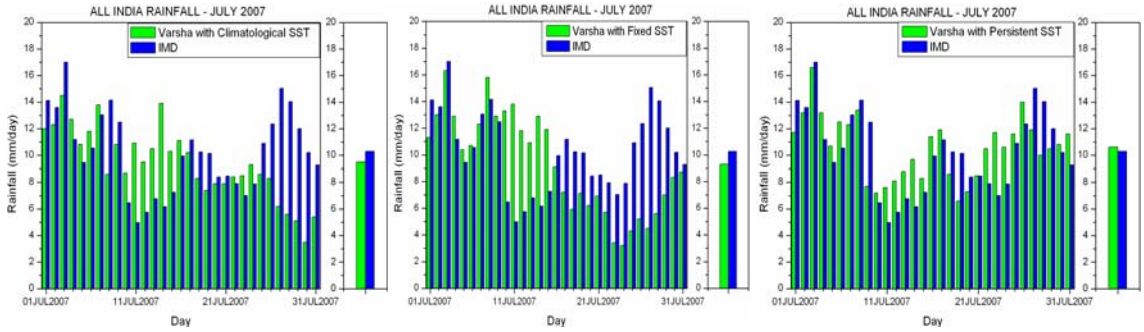
Fig 3. 1st day rainfall forecast with different specific humidity approximations



(a) Method 1 (b) Method 2 (c) Method 3

Fig 4. 10th day rainfall forecast with different specific humidity approximations

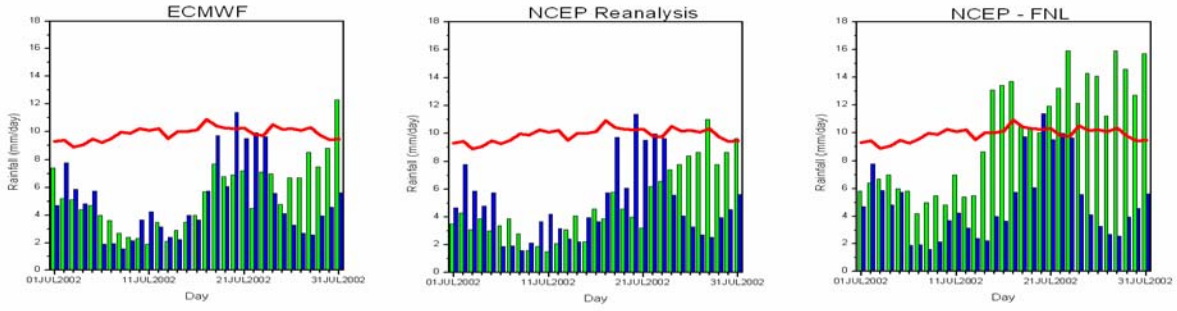
2. The all India daily and monthly rainfall predicted by Varsha using the initial condition of 01 July 2007 (fig 2) and climatological, fixed and persistent SSTs with the IMD observations are shown in figure 5 (a-c). The all India rainfall predicted with persistent SST is very well matched with the observed daily rainfall than that predicted with climatological SST and fixed SST. The correlation analysis carried out shows that the rainfall predicted using the persistent SST method is better correlated to the actual observation. The correlation values for persistent, fixed and climatological SST are 0.66, 0.094 and 0.05 respectively. From the figures it is clear that the forecasts using persistent SST could simulate the daily rainfall variations better than the other two forecasts.



(a) Climatological SST (b) Fixed SST (c) Persistent SST

Fig 5. Daily and Monthly Rainfall forecast with different SST and observation for 01 JUL 2007

3. Figure 6 shows the forecasts with initial conditions of 01 July 2002 from ECMWF, Reanalysis and FNL data of NCEP and the observations from IMD. It can be noted that, using ECMWF and Reanalysis data the model could simulate the drought of 2002. The high resolution FNL data, even though it is from the same centre, which gives the reanalysis data, could not predict the daily rainfall accurately. The correlation analysis for all India rainfall carried out shows the forecast with ECMWF is better correlated with the observations, the correlation values being 0.40, 0.50 and 0.77 for FNL, reanalysis and ECMWF data respectively.



(a) ECMWF (b) NCEP Reanalysis (c) NCEP - FNL

Fig 6. All India daily rainfall forecast with IC from different sources and observation (01JUL2002)

5 CONCLUSION

The influence of various input parameters and the initial conditions from various sources on forecasts is studied using Varsha GCM. The results show that the initial conditions of various parameters have a crucial role in weather forecast. As for the SST, The persisted anomaly method provides a better forecast. It is also seen that the ECMWF data gives the better initial conditions to the model than other sources.

References

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[6] website: http://dss.ucar.edu/datasets/ds083.2/